PATENT ABSTRACTS OF JAPAN

(11)Publication number : 08-107148

(43)Date of publication of application : 23.04.1996

(51)Int.Cl. H01L 21/768
H01L 21/3205

(21)Application number : 07-199976

(22)Date of filing : 04.08.1995

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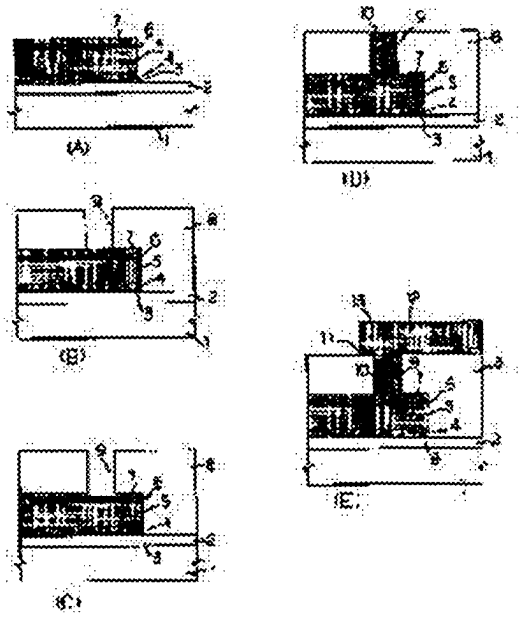
(30)Priority

Priority number : 06188271 Priority date : 10.08.1994 Priority country : JP

(54) WIRING STRUCTURE AND FORMING METHOD THEREOF

(57)Abstract:



PURPOSE: To realize a method of forming a wiring structure, wherein a lower wiring is excellent in patterning accuracy, and a contact resistance between a plug and the lower wiring is low enough when the lower wiring and upper wiring are connected together with the plug.

CONSTITUTION: A conductive layer of laminated structure composed of a Ti thin film 6 and a TiN thin film 7 is formed on the surface of an Al alloy film 5, the Al alloy film 5 and the conductive layer are patterned through a lithography technique, an Si oxide film 8 is deposited on the Al alloy film 5 and the conductive layer, and a contact hole 9 reaching to the conductive layer is provided to the Si oxide film 8. After the contact hole 9 is formed, the TiN thin film 7 exposed at the bottom of the contact hole 9 is removed by etching, a tungsten plug 10 is buried in the contact hole 9 through a selective CVD method, and an Al alloy film 12 is formed so as to be electrically connected to the tungsten plug 10.

LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to wiring structure and its formation approach, and relates to a multilayer interconnection in detail.
[0002]
[Description of the Prior Art] In recent years, in the multilayer interconnection adopted as high integrated semiconductor equipment, improvement in the dependability of the reduction in resistance of the contact between wiring (beer contact) and wiring is called for. And high integration of a semiconductor device is progressing increasingly and making small the path of a contact hole (suppose that a beer hall is also synonymous) is called for. However, if the path of a contact hole is made small, it will become difficult to make the wiring material of thickness sufficient in a contact hole deposit. Then, forming the plug which is made to deposit proper metals (a tungsten, aluminum, nickel, copper, etc.) in a contact hole, and connects the 1st-layer wiring and the 2nd-layer wiring with a CVD method is proposed (refer to JP,4-264721,A (H01L21/285)).
[0003] That is, after forming a titanium nitride thin film on the 1st wiring layer which consists of an aluminum-Si alloy and covering a wiring layer by the insulator layer, the contact hole which leads to the titanium nitride film is formed in this insulator layer, with a selection CVD method, a tungsten plug is grown up on a titanium nitride thin film, the inside of a contact hole is embedded, and the 2nd wiring layer which consists of an aluminum-Si alloy so that a plug may be contacted is formed further.
[0004] Especially, in this conventional example, since it is hard to carry out selective growth of the tungsten on a titanium nitride thin film, the specific resistance of a titanium nitride thin film has been set below to 300-ohmcm (for example, 100-ohmcm).
[0005]
[Problem(s) to be Solved by the Invention] If it is in the conventional example, it has a trouble as follows.
1) The contact resistance between a tungsten plug and a nitriding Ti thin film is high.
2) The variation in the contact resistance between a tungsten plug and a nitriding Ti thin film is large (especially this problem is so remarkable that the path of a contact hole becomes small).
[0006] This invention cancels this trouble about wiring structure and its formation approach.
[0007]
[Means for Solving the Problem] The wiring structure of claim 1 makes the conductive matter with good connection resistance with this plug intervene between a conductive layer and a conductive plug. Moreover, a bottom conductive layer and an upper conductive layer are connected through the conductive plug formed in the contact hole, and on said bottom conductive layer, the wiring structure of claim 2 has good contact resistance with said conductive plug, and it forms the electric conduction film which consists of matter which has the acid-resisting effectiveness at the time of lithography, and forms said conductive plug on this electric conduction film.
[0008] Moreover, the wiring structure of claim 3 connected the bottom conductive layer and the upper

conductive layer through the conductive plug formed in the contact hole, and while forming the electric conduction film which consists of at least two kinds of laminated structures on said bottom conductive layer, the management of the part where said electric conduction film contacts said plug is lacked. Moreover, it consists of matter with the acid-resisting effectiveness said electric conduction film consists of matter with the lower layer part good [connection resistance with said conductive plug], and good [the wiring structure of claim 4 / a part for a management] at the time of lithography.
[0009] Moreover, the wiring structure of claim 5 connects lower layer wiring and the upper wiring through the tungsten plug formed in the contact hole, and while forming the electric conduction film which consists of titanium film and titanium nitride film on it after said lower layer wiring, said titanium nitride film of the part which contacts said plug at least was lacked, and said plug is in contact with said titanium film, and contains **.
[0010] Moreover, the wiring structure of claim 6 forms said conductive plug or a tungsten plug with a selection CVD method. Moreover, between a conductive layer and a conductive plug, connection resistance with this plug prepares the good conductive matter, and the formation approach of the wiring structure of claim 7 carries out selective growth of said conductive plug on it.
[0011] Moreover, the process at which the formation approach of the wiring structure of claim 8 forms in the front face of a bottom conductive layer the electric conduction film which consists of at least two kinds of laminated structures, The process which carries out patterning of said bottom conductive layer and the electric conduction film, and the process which forms the contact hole which deposits an interlayer insulation film on said bottom conductive layer and the electric conduction film, and leads to this interlayer insulation film at said electric conduction film, The process which carries out etching removal of the management of said electric conduction film exposed to said contact hole pars basilaris ossis occipitalis after formation and coincidence of said contact hole, or formation, The process which embeds a conductive plug in said contact hole, and the process which forms an upper conductive layer so that it may flow electrically to said conductive plug are included.
[0012] Moreover, said electric conduction film consists of matter with the lower layer part good [connection resistance with said conductive plug], and, as for the formation approach of the wiring structure of claim 9, the amount of management consists of good matter of the acid-resisting effectiveness at the time of lithography. Moreover, the formation approach of the wiring structure of claim 10 forms said conductive plug with a selection CVD method.
[0013] Moreover, the process at which the formation approach of the wiring structure of claim 11 forms in the front face of a bottom conductive layer the electric conduction film which consists of a laminated structure of the titanium film and the titanium nitride film on it, The process which carries out patterning of said bottom conductive layer and the electric conduction film, and the process which forms the contact hole which deposits an interlayer insulation film on said bottom conductive layer and the electric conduction film, and leads to this interlayer insulation film at said electric conduction film, The process which carries out etching removal of said titanium nitride film exposed to said contact hole pars basilaris ossis occipitalis after formation and coincidence of said contact hole, or formation, The process which embeds a tungsten plug with a selection CVD method in said contact hole, and the process which forms an upper conductive layer so that it may flow electrically to said tungsten plug are included.
[0014] Moreover, the formation approach of the wiring structure of claim 12 deposits an interlayer insulation film on a bottom conductive layer, and includes the process which forms the contact hole which leads to this interlayer insulation film at said bottom conductive layer, the process which forms the titanium compound film in the base and inside of said contact hole at least, the process which forms a conductive plug in said contact hole, and the process which forms an upper conductive layer so that it may flow electrically to said conductive plug.
[0015] Moreover, the process at which the formation approach of the wiring structure of claim 13 forms in the front face of a bottom conductive layer the electric conduction film which consists of at least two kinds of laminated structures, The process which carries out patterning of said bottom conductive layer and the electric conduction film, and the process which forms the contact hole which deposits an interlayer insulation film on said bottom conductive layer and the electric conduction film, and leads to

this interlayer insulation film at said electric conduction film, The process which forms the titanium compound film in the base and inside of said contact hole at least, the process which forms a conductive plug in said contact hole, and the process which forms an upper conductive layer so that it may flow electrically to said conductive plug are included.
[0016] Moreover, the formation approach of the wiring structure of claim 14 carries out etching removal of said some of electric conduction film [at least] exposed to said contact hole pars basilaris ossis occipitalis after formation and coincidence of said contact hole, or formation. Moreover, the formation approach of the wiring structure of claim 15 forms said conductive plug with the technique and etchback technique which form the good metal membrane of covering nature like a blanket tungsten CVD method.
[0017] Moreover, as for the formation approach of the wiring structure of claim 16, the amount of the management uses the good matter of the acid-resisting effectiveness as said electric conduction film at the time of lithography. Moreover, the process at which the formation approach of the wiring structure of claim 17 forms in the front face of a lower layer wiring layer the electric conduction film which consists of a laminated structure of the titanium film and the titanium nitride film on it, The process which carries out patterning of said lower layer wiring layer and the electric conduction film, and the process which forms the contact hole which deposits an interlayer insulation film on said lower layer wiring layer and the electric conduction film, and leads to this interlayer insulation film at said electric conduction film, The process which carries out etching removal of said titanium nitride film exposed to said contact hole pars basilaris ossis occipitalis after formation and coincidence of said contact hole, or formation, With the process which forms the titanium nitride film in the base and inside of said contact hole at least, and a blanket tungsten CVD method By carrying out etchback of said tungsten material to the process which forms tungsten material in a front face including the inside of said contact hole The process which forms a tungsten plug in said contact hole, and the process which forms the upper wiring layer so that it may flow electrically to said tungsten plug are included.
[0018] That is, if it is in this invention, when contact resistance with said plugs, such as titanium, makes the good conductive matter intervene between wiring (bottom conductive layer) and a conductive plug, good electrical characteristics are acquired. Moreover, on said conductive matter, the laminating of the good matter of the acid-resisting effectiveness, such as titanium nitride, is carried out, the patterning precision by lithography is raised at the beginning, it is lacking in this upper matter after that, and a plug is made into the structure where said conductive matter is contacted.
[0019] When titanium nitride is especially used as antireflection film, using titanium as conductive matter, Although a selection CVD method is used and it is hard to grow up a tungsten on this titanium nitride By contact resistance with tungsten plugs, such as titanium's, forming the good matter on a bottom conductive layer, and carrying out the laminating of the good matter of the acid-resisting effectiveness, such as titanium nitride, on it as above-mentioned If the titanium nitride film is removed before the selective growth of a tungsten, what has a good patterning precision of a bottom conductive layer and the good both sides of contact resistance with a plug and a bottom conductive layer will be obtained.
[0020] Moreover, titanium compound film like [the adhesion over a substrate is high as substrate film formed before performing the technique which forms the good metal membrane of covering nature like a blanket tungsten CVD method, and] titanium nitride without a fear of the film separating from the end face of a substrate etc. is used.
[0021]
[Embodiment of the Invention]
(The 1st operation gestalt) The 1st operation gestalt which materialized this invention to two-layer wiring is explained based on drawing 1 . Drawing 1 is the sectional view having shown the manufacture process of the semiconductor device which adopted the wiring structure of the 1st operation gestalt, and explains order later on below.
[0022] Process 1 (refer to drawing 1 A): Form silicon oxide 2 of 600nm of thickness by the CVD method, the oxidizing [thermally] method, etc. on the single crystal silicon substrate 1. Furthermore,

the titanium (Ti) thin film 3 (50nm of thickness), the titanium nitride (TiN) thin film 4 (100nm of thickness), the aluminum containing alloy film 5 (aluminum-Si(1%)-Cu (0.5%)) (500nm of thickness), the Ti thin film 6 (30nm of thickness), and the TiN thin film 7 (20nm of thickness) are formed from the bottom one by one on said Si oxide film 2 using the magnetron sputtering method.
[0023] Said Ti thin film 3 and the TiN thin film 4 function as a barrier metal for making it aluminum and Si not react. Moreover, said Ti thin film 6 and the TiN thin film 7 (especially TiN thin film 7) prevent that light reflects in aluminum at a lithography process, and function as the so-called cap metal with which it is made for the reflected light not to influence a resist. And patterning of said barrier metal, the aluminum containing alloy film 5, and the cap metal is carried out to a predetermined configuration through resist (illustration abbreviation) spreading, exposure, and etching with the usual lithography technique and dry etching techniques (the RIE method etc.).
[0024] Process 2 (refer to drawing 1 B): Deposit the Si oxide film 8 (600nm of thickness) with a CVD method on said TiN thin film 7 and said exposed Si oxide film 2. Furthermore, the contact hole 9 which reaches said Si oxide film 8 at said TiN thin film 7 is formed through resist (illustration abbreviation) spreading, exposure, and etching with the usual lithography technique and dry etching techniques (the RIE method etc.).
[0025] process 3(refer to drawing 1 C): -- said TiN thin film 7 which uses said Si oxide film 8 as a mask, and hits the pars basilaris ossis occipitalis of said contact hole 9 -- RIE (Reactive Ion Etching) -- etching removal is carried out by law. Etching conditions are used gas:CHF320sccm, CF420sccm, pressure:300Torr, and power:500W. In addition, this process 3 may be performed to forming a contact hole 9 in a process 2, and coincidence.
[0026] Process 4 (refer to drawing 1 D): Carry out selective growth of the tungsten plug 10 only into said contact hole 9 with a selection tungsten-CVD method. As growth conditions, although temperature:300 degree C, pressure:10mTorr, and an used gas:6 fluoride [tungsten] (WF6, flow rate 10sccm) + mono silane (SiH4, flow rate 6sccm) (gas-stream quantitative ratio: SiH4/WF 6= 0.6) are suitable, the range of temperature is 250 degrees C - 350 degrees C, and a gas stream quantitative ratio (SiH4/WF6) can be suitably adjusted in 0.5-0.8.
[0027] Process 5 (refer to drawing 1 E): The sputter etching using inert gas (for example, Ar) removes the oxide film of tungsten plug 10 front face etc. Next, the Ti thin film 11 (50nm of thickness), aluminum alloy film 12 (aluminum-Si(1%)-Cu (0.5%)) (500nm of thickness), and the TiN thin film 13 (20nm of thickness) are formed from the bottom one by one on said tungsten plug 10 and the Si oxide film 8 using the magnetron sputtering method.
[0028] And patterning of the Ti thin film 11, the aluminum containing alloy film 12, and the TiN thin film 13 is carried out to a predetermined configuration through resist (illustration abbreviation) spreading, exposure, and etching with the usual lithography technique and dry etching techniques (the RIE method etc.). Drawing 2 shows relation with contact resistance with the path of the contact hole when growing up a tungsten with a selection CVD method into a contact hole, and the substrate film in the structure of a **** 1 operation gestalt.
[0029] When selective growth of the tungsten is carried out on a TiN thin film like before so that clearly from this experimental result, compared with this invention, contact resistance of variation is highly large relatively, and moreover, it turns out that that inclination becomes strong as the path of a contact hole becomes small. If it was in the 1st operation gestalt like the above, since the TiN thin film 7 in which a tungsten cannot carry out selective growth easily was removed before growing up a tungsten and connection resistance with a tungsten made the good Ti thin film 6 the substrate at the time of selective growth, even if the path of a contact hole 9 is small, a good tungsten plug can be formed.
[0030] In addition, although considered as the two-layer structure of the Ti thin film 6 and the TiN thin film 7 as a cap metal, contact resistance with a tungsten should have the just good part which it does not limit to two-layer, and the maximum upper layer has the acid-resisting effectiveness in short, and contacts the tungsten plug 10. Moreover, you may be a monolayer as long as the cap metal itself has the acid-resisting effectiveness and good contact resistance. For example, if a plug 10 is a tungsten, it is also good to accept it Ti thin film 6. Although the acid-resisting effectiveness is inferior in the Ti thin film 6

compared with the TiN thin film 7, it fully goes into tolerance.
(The 2nd operation gestalt) The 2nd operation gestalt which materialized this invention to two-layer wiring is explained based on a drawing.
[0031] Drawing 3 - drawing 8 are the sectional views having shown the manufacture process of the semiconductor device which adopted the wiring structure of the 2nd operation gestalt, and explain order later on below.
Process (1) (refer to drawing 3): Form silicon oxide 22 of 600nm of thickness by the CVD method, the oxidizing [thermally] method, etc. on the single crystal silicon substrate 21. Furthermore, the titanium (Ti) thin film 23 (50nm of thickness), the titanium nitride (TiN) thin film 24 (100nm of thickness), the aluminum containing alloy film 25 (aluminum-Si(1%)-Cu (0.5%)) (500nm of thickness), the Ti thin film 26 (30nm of thickness), and the TiN thin film 27 (20nm of thickness) are formed from the bottom one by one on said Si oxide film 22 using the magnetron sputtering method.
[0032] Said Ti thin film 23 and the TiN thin film 24 function as a barrier metal for making it aluminum and Si not react. Moreover, said Ti thin film 26 and the TiN thin film 27 (especially TiN thin film 27) prevent that light reflects in aluminum at a lithography process, and function as the so-called cap metal with which it is made for the reflected light not to influence a resist.
[0033] And patterning of said barrier metal, the aluminum containing alloy film 25, and the cap metal is carried out to a predetermined configuration through resist (illustration abbreviation) spreading, exposure, and etching with the usual lithography technique and dry etching techniques (the RIE method etc.).
Process (2) (refer to drawing 4): Deposit the Si oxide film 28 (600nm of thickness) with a CVD method on said TiN thin film 27 and said exposed Si oxide film 22. Furthermore, the contact hole 29 which reaches said Si oxide film 28 at said TiN thin film 27 is formed through resist (illustration abbreviation) spreading, exposure, and etching with the usual lithography technique and dry etching techniques (the RIE method etc.).
[0034] Process (3) (refer to drawing 5): Use said Si oxide film 28 as a mask, and carry out etching removal only of said TiN thin film 27 which hits the pars basilaris ossis occipitalis of said contact hole 29 by the RIE method. Etching conditions are used gas:CHF320sccm, CF420sccm, pressure:300Torr, and power:500W. In addition, this process (3) may be performed to forming a contact hole 29 in a process (2), and coincidence.
[0035] Process (4) (refer to drawing 6): By the sputter etching using inert gas (for example, Ar), use the magnetron sputtering method and form the titanium nitride (TiN) thin film 30 (100nm of thickness) in the base of said contact hole 29 and an inside, and the front face that is said Si oxide film 28 further, after cleaning the inside of a contact hole 29.
[0036] Process (5) (refer to drawing 7): Form a tungsten with a blanket tungsten CVD method on said TiN thin film 30 including the inside of said contact hole 29. As formation conditions, although temperature:450 degree C, pressure:80Torr, and used gas:6 fluoride [tungsten] (WF6, flow rate 70sccm) + hydrogen (H2, flow rate 420sccm) (gas-stream quantitative ratio: H2/WF 6= 6) are suitable, the range of temperature is 425 degrees C - 475 degrees C, and a gas stream quantitative ratio (H2/WF6) can be suitably adjusted in 5-70.
[0037] And the tungsten plug 31 is formed in said contact hole 29 by carrying out whole anisotropy surface etchback of the formed tungsten, and processing it so that a tungsten may become flat-tapped with the front face of the Si oxide film 28.
Process (6) (refer to drawing 8): The sputter etching using inert gas (for example, Ar) removes the oxide film of tungsten plug 31 front face etc. if needed.
[0038] Next, aluminum alloy film 32 (aluminum-Si(1%)-Cu (0.5%)) (500nm of thickness) and the TiN thin film 33 (20nm of thickness) are formed from the bottom one by one on said tungsten plug 31 and the TiN thin film 30 using the magnetron sputtering method. And patterning of the aluminum containing alloy film 32 and the TiN thin film 33 is carried out to a predetermined configuration through resist (illustration abbreviation) spreading, exposure, and etching with the usual lithography technique and dry etching techniques (the RIE method etc.).

[0039] In the structure of a **** 2 operation gestalt, drawing 9 can be lowered low still enough, although contact resistance is higher than the structure of the 1st operation gestalt a little by showing relation with contact resistance with the path of the contact hole when growing up a tungsten with a blanket tungsten CVD method into a contact hole, and the substrate film, and forming a TiN thin film all over a growth side before CVD.
[0040] In addition, among drawing, with a **** 2 operation gestalt, - mark replaces with a TiN thin film, and ** mark uses a TiN/Ti thin film. Although the contact resistance also with the low structure of this TiN/Ti thin film is obtained, compared with TiN, the adhesion of Ti over a substrate is bad, and it is easy to separate from the edge surface part of a substrate. In addition, this invention is not limited to the above operation gestalt, and may be carried out as follows.
[0041] ** As the approach of sputtering, diode sputtering, RF sputtering, 4 pole sputtering, etc. are needed in addition to magnetron sputtering.
** The reactant ion beam etching (called RIBE and reactant ion milling) which used reactant gas (for example, CCl4, SF6) as the approach of sputter etching besides using inert gas may be used.
[0042] ** Silicon oxide may be formed by approaches other than a CVD method (PVD, such as a spatter and vacuum deposition, oxidation style).
** Silicon oxide may be transposed to other insulator layers (various silicate glass, an alumina, a silicon nitride, titanic-acid-ized film, etc.).
** In the 1st operation gestalt, the tungsten plug 10 may be transposed to the plug by other metals (aluminum, nickel, copper, molybdenum, etc.). In this case, in consideration of the acid-resisting effectiveness, contact resistance, etc., it may replace with the Ti thin film 6 or the TiN thin film 7, and other conductive material may be used suitably.
[0043] ** In the 2nd operation gestalt, the tungsten plug 31 may be transposed to the plug by other metals (aluminum, nickel, copper, molybdenum, etc.).
** In the 2nd operation gestalt, if it may replace with the TiN thin film 30, a TiW thin film is sufficient and a titanium compound is used in short, low contact resistance is obtained and adhesion with a substrate is also good.
[0044]
[Effect of the Invention] If it is in the wiring structure and its manufacture approach of this invention, when contact resistance with said plugs, such as titanium, makes the good conductive matter intervene between wiring and a conductive plug, good electrical characteristics can be acquired. And on said conductive matter, the laminating of the good matter of the acid-resisting effectiveness, such as titanium nitride, is carried out, the patterning precision by lithography is raised at the beginning, and it is lacking in this upper matter after that, and since a plug is made into the structure where said conductive matter is contacted, what has a good patterning precision of lower layer wiring and the good both sides [wiring / a plug and / lower layer] of contact resistance is obtained.
[0045] Moreover, by forming the titanium compound film in the substrate as an adhesion layer, there are no worries in a substrate edge about film peeling in the case of conductive plug formation, and low contact resistance can be obtained at it.

[Translation done.]